CLOUD PHYSICS LIDAR

PAYLOAD DATA PACKAGE

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CPL QUICK REFERENCE DATA SHEET

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Payload / Mission Name: CPL for Aura Validation Experiment (AVE)

Mission Profile / Number of Flights Requested: n/a

Requested Flight Dates: Oct 18 – Nov 12, 2004

Payload Installation Location on Airplane: Pallet bay.

Payload Overall Assembly Weight: 281 lbs (not including WB-57 pallet)

Gas/Cryogenic Cylinder Requests: None.

List any Hazardous Materials to be used: Methanol, for cleaning optics (on ground).

Overboard Vent Requests and Type of Gas to be Vented: None.

Payload Power Requirement: 5 Amps 110VAC 400 Hz; 30 Amps 110VAC 400 Hz (10 Amps per phase); and two (2) 35 Amp 28VDC circuits.

Ground Laboratory Work Space Request: Space for storage and work space for CPL data processing (maximum of 2 people).

Computer Network Access Requests: 2 network connections.

Sheet Metal Work Requests: None.

Electrical Wiring Requests: None.

Miscellaneous Requests: None.

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1. Payload Description

1.1 Overview

The Cloud Physics Lidar (CPL) was specifically designed for use on the ER-2 aircraft and was first deployed in 2000. The CPL provides high resolution profiles of clouds, aerosols, and smoke layers for use in cloud and radiation studies. Figure 1.1 displays a typical example of the CPL data, showing boundary layer aerosol, cloud structure, and dust.

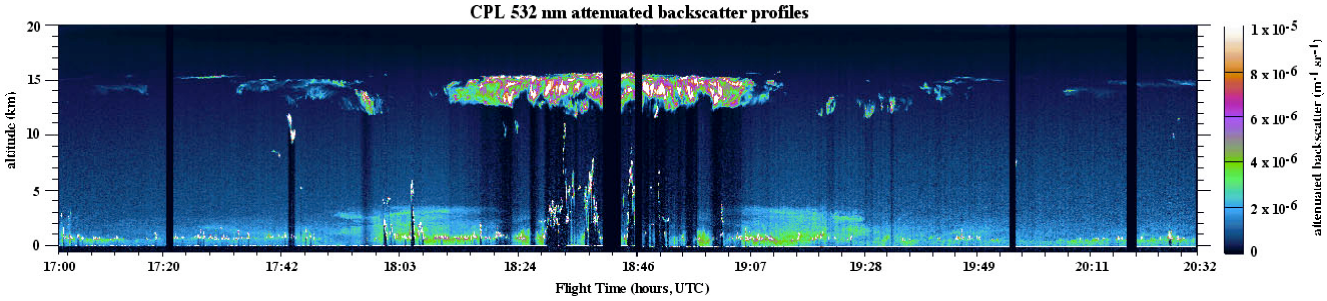


Figure 1.1: Example of CPL data from the CRYSTAL-FACE campaign, July 26, 2002. Data shows boundary layer aerosol, clouds and multiple cloud layers, and Saharan dust (in the center of the image). Cloud shadows are present whenever the lidar signal cannot penetrate through a layer.

The CPL is a state-of-art system employing a solid-state, diode-pumped, conductively cooled laser operating at 5 kHz repetition rate (there is an optional 1 kHz mode). The laser simultaneously transmits 1064 nm, 532 nm, and 355 nm radiation. The receiver uses solid-state photon-counting detectors to measure the backscattered light at all three wavelengths. In addition, the 1064 nm signal is used for a depolarization measurement. Measuring the backscattered signal at three wavelengths provides information about cloud and aerosol optical properties. The depolarization measurement can be used to determine the molecular phase of clouds.

After construction, the CPL was immediately deployed on the SAFARI-2000 field campaign during August and September 2000. Since 2000, the CPL has participated in the CRYSTAL-FACE, TX-2002, THORPEX-Pacific, THORPEX-Atlantic, and GLAS validation missions, all using the ER-2 aircraft. Details of the CPL instrument and the CPL data archive can be found at the CPL web site: http://cpl.gsfc.nasa.gov

The CPL instrument package consists of 4 components: a sealed box that houses the optical components, a rack mount box containing the data system, a rack mount box containing the laser power supply, and an ER-2 interface rack. We refer to this collection of four components as the CPL instrument. Figure 2 shows the CPL instrument in normal ER-2 configuration. To adapt CPL to the WB-57, we are simply bolting the entire assembly, including the ER-2 interface rack, to the WB-57 pallet. To accomplish this, we designed an interface ("WB-57 rack") that mounts the CPL to the WB-57 pallet (see Figure 2.1 in Section 2).

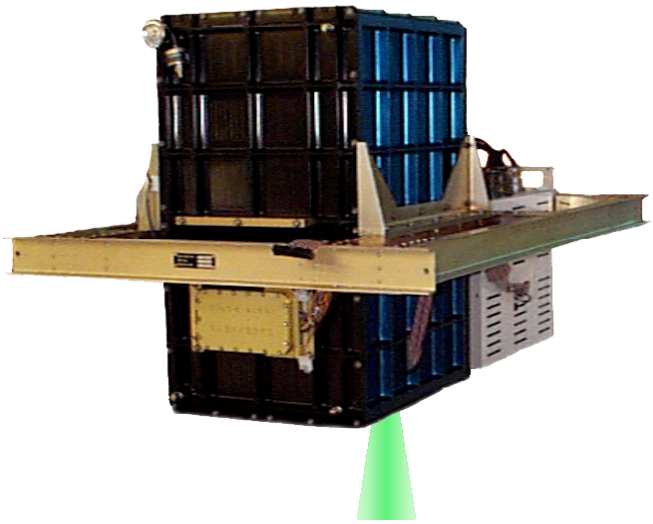


Figure 1.2: The CPL instrument in ER-2 configuration. The gold frame is the ER-2 interface rack, the black/blue box houses the instrument, and mounted behind the box on the rack are the data system and laser power supply boxes. To adapt to the WB-57, this entire assembly is bolted to the WB-57 pallet using what we term a "WB-57 interface rack."

The blue/black sealed box shown in Figure 1.2 houses the CPL optical system. The optical system consists of the laser transmitter, receiving telescope, optics, and detectors. Figure 1.3 shows the components that are housed in the sealed (but not pressurized) box.

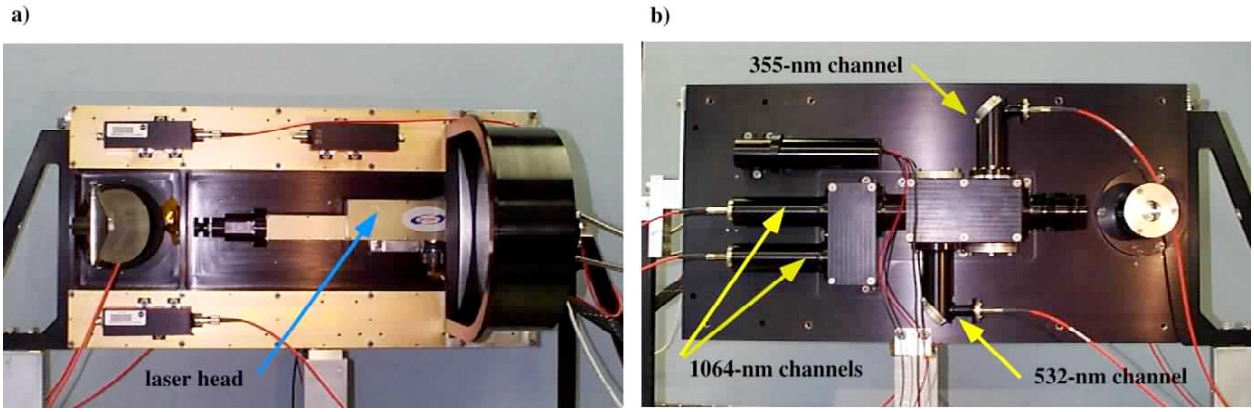


Figure 1.3: CPL optical bench. This assembly is housed in the large blue/black box shown in Figure 1.2. One side of the bench (left side of figure) holds the laser and telescope; other side (right side of figure) holds the receiver optics.

The CPL requires an optical window in the pallet floor to permit transmission and reception of laser light. We have designed and fabricated our own custom pallet floor that will hold a 10-inch diameter window. Because we are flying in the unpressurized pallet, this window does not need to be proof tested. Drawings of the pallet floor were provided to the WB-57 engineer, and a photo of the completed floor is shown in Figure 1.4.

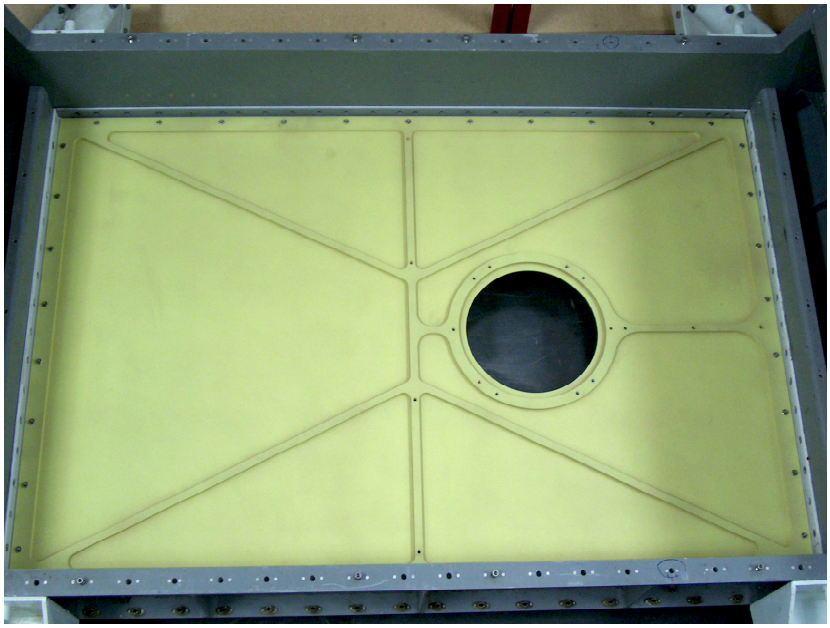


Figure 1.4: CPL pallet floor. A 10-inch diameter optical window will be placed in the open area. The floor is not load-bearing, as the CPL instrument mounts only to the pallet walls.

1.2 CPL Electrical Requirements

The CPL payload uses both DC and AC power, and uses two pilot switches. This section will describe the electrical requirements.

The CPL payload uses two pilot control switches. One switch (here termed 'S1') controls the data system. Activation of S1 boots the data system and initiates data acquisition. The fail light associated with S1 will remain ON for about 1 minute, until the data system is fully operational and a watchdog command has verified proper operation. A second switch (here termed 'S2) controls laser emission. The fail light associated with S2 will extinguish immediately upon activation of S2, *provided* the data system (S1) is powered and functional (no S1 fail light). Should either fail light turn ON during operation, fail procedures are provided in Section 9.5. It is important to note that although the CPL payload may be powered (i.e., area power ON), laser emission is inhibited until S2 is activated.

One circuit on one AC power connector is used to power the data system and detectors (uses

phase-A of the circuit only). This circuit is fused at 5 Amps. One circuit on one DC connector is used to power the laser and internal heaters. This circuit is split, with the laser fused at 20 Amps and the heaters fused at 15 Amps. The second circuit on that DC connector powers survival heaters and is fused at 35 Amps. One circuit on a second AC connector is used exclusively for heaters, with each phase of the circuit fused at 10 Amps. Table 1 gives a break-out of the CPL electrical requirements.

Table 1: CPL electrical connector definitions

	Experimenter panel receptacle identifier	**Fusing (at CPL instrument)**	**Use**	**Notes**
Pilot control switch	J1-J5	n/a	Controls initiation of CPL data acquisition	Also provides navigation data to data system
Pilot control switch	J1-J5	n/a	Controls laser emission	
AC circuit 1	J6-J10	Circuit 1, phase-A: 5 Amps	Powers data system, detectors	AC circuit 2, DC circuit 1, and DC circuit 2 on this connector not used
DC circuit 1	J11-J12	Circuit 1: 15 Amps and 20 Amps (splits at CPL interface) Circuit 2: 35 Amps	Powers laser and heaters Powers survival heaters	
AC circuit 1	J6-J10	Circuit 1: phase-A 10 Amps Circuit 1, phase-2 10 Amps Circuit 1, phase-3 10 Amps	Powers survival heaters	AC circuit 2, DC circuit 1, and DC circuit 2 on this connector not used

In summary, the CPL payload uses two of the J1-J5 pilot connectors, two of the J6-J10 power connectors, and one of the J11-J12 power connectors.

2 Structural Analysis

Figure 2.1 shows the CPL instrument configuration for the WB-57. Structural analysis has been completed for all assemblies, per WB-57 requirements.

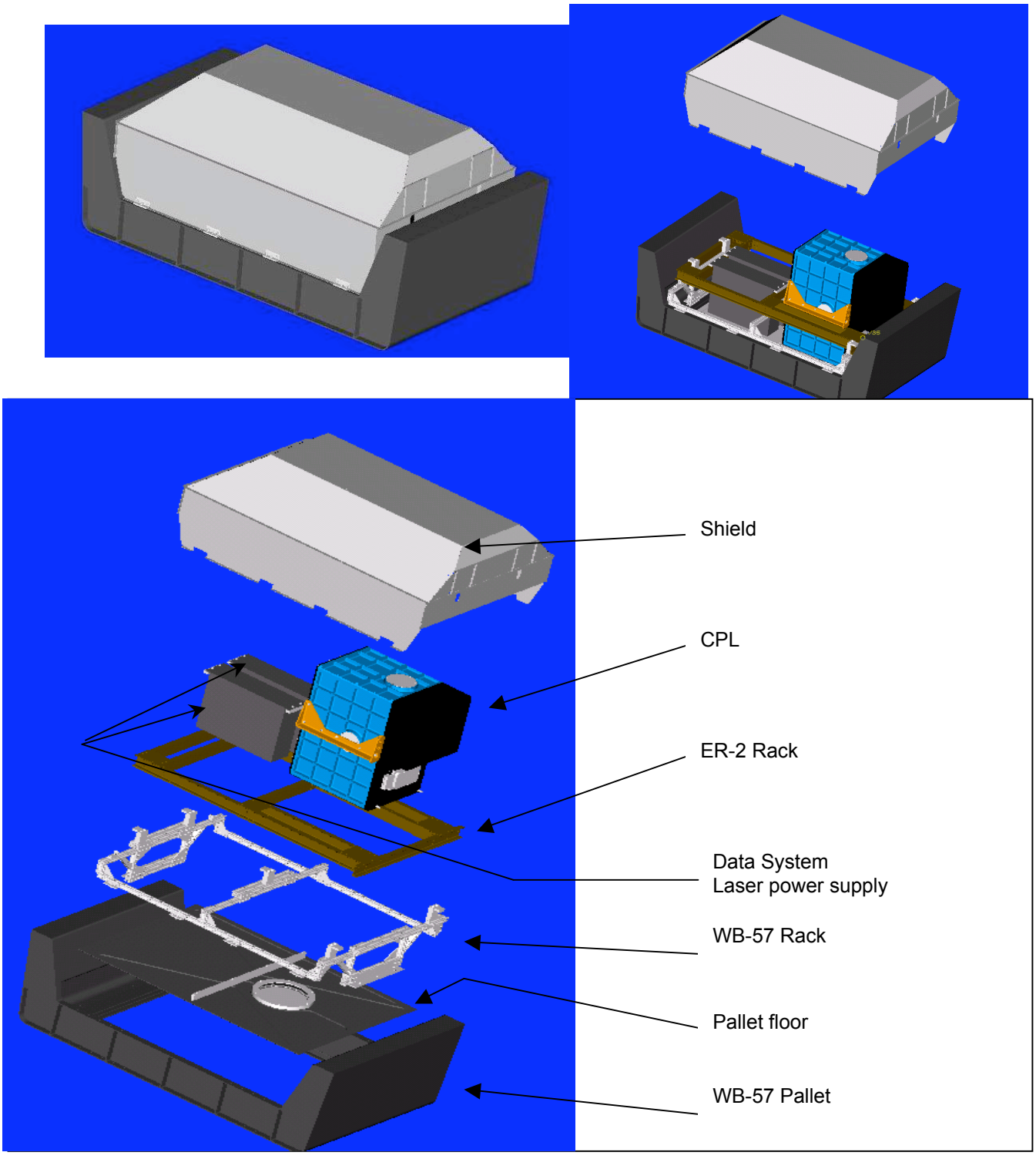


Figure 2.1: CPL solid model showing layout and labeling of component parts.

2.1 Weight

Part/assembly name	Material used	Weight (lbs)
CPL instrument box	(enclosure made of 6061-T651)	175 lbs
Shield	Aluminum Alloy	19 lbs
Data system	Various	25 lbs
Laser Power Supply	Various	25 lbs
ER-2 Rack	Aluminum Alloy	20 lbs
WB-57 Rack	6105-T5	27 lbs

Note: weight does not include the pallet floor or the WB-57 pallet.

2.2 Welds

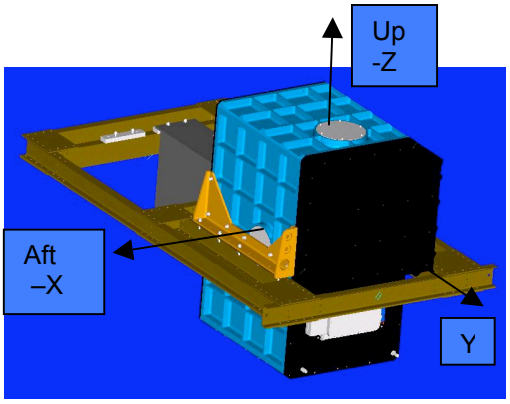
There are no welds.

2.3 Design Calculations

In the Section 2.3 the following axis definitions and g-loadings are used:

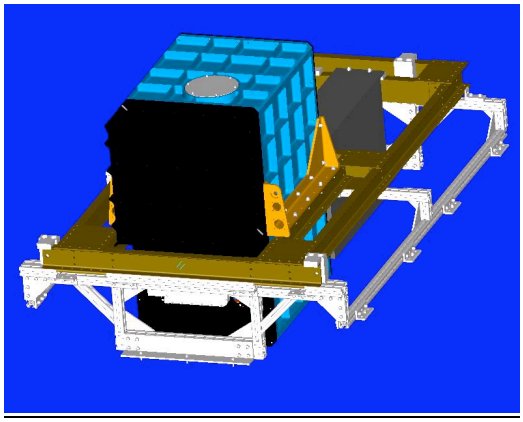
X is the forward axis…Forward: 3.0 g's
Aft: 1.5 g's
Y is the lateral axis… Lateral both directions: 1.5 g's
Z is elevation axis…. Up: 2.0 g's
Down: 4.5 g's

Subsystem 1: (CPL/ Data System/ER2 Rack)



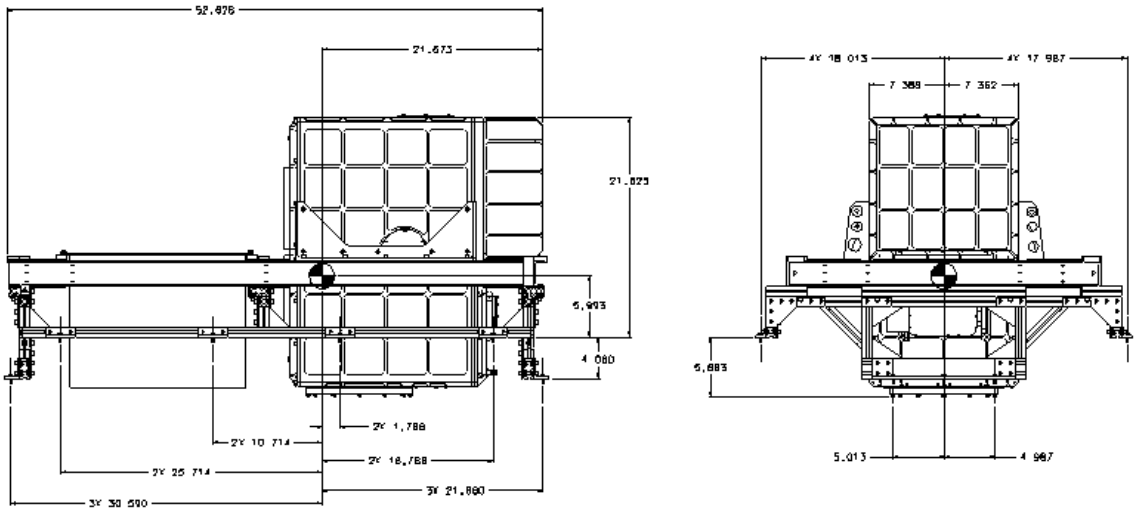
Each bracket attached to CPL using seven (7) 1/4-20 bolts; axis of the bolts is the X axis.
Each bracket attached to ER2 Rack using five (5) #10 bolts; axis of the bolts is the Z axis.
Data system and power supply attached to ER2 Rack using four (4) 1/4-20 bolts; axis of the bolts is the Z axis.

Subsystem 2: (subsystem 1 + WB57 rack)

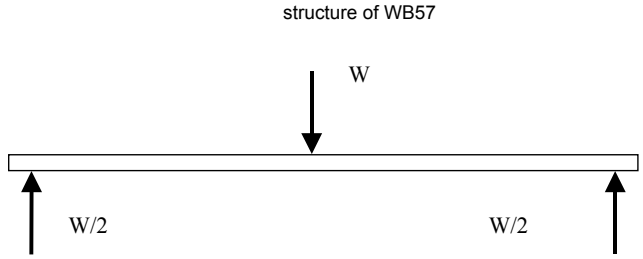


Subsystem1 is supported by an 80/20 extrusion assembly, composed of 3 transversal bars.
Subsystem1 is clamped on to the WB-57 Rack using five (5) clamps, each bolted with two (2) 1/4-20 bolts per clamp (along Z axis).
Four (4) safety stops are also used on the X-axis and bolted to the frame via 1/4-20 bolts (2 per stop along Z axis). These serve primarily to locate the subsystem 1.

SUBSYSTEM 2 CENTER OF GRAVITY



Following is a beam analysis in worse case scenario for the 1010 and 1020 80/20 brand Aluminum extrusion used in the WB-57 Rack assembly.



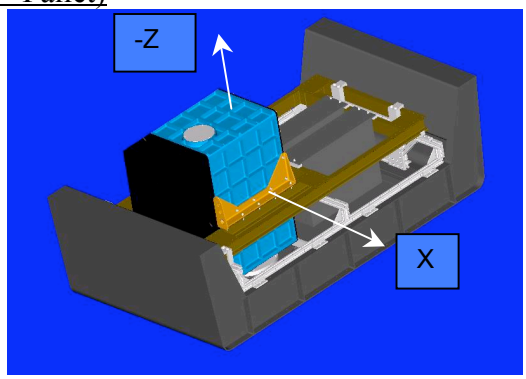
Stress at center	" - WL / 8 Z "

Maximum deflection at center	"1/192 * (Wl^3 /EI) "

	W:	worst case load	100	lbs	(total load 300 on 3 beams)		
		g factor 4.5	450	lbs			
	L :		36	"			
1020 series	I :		0.0826334	"^4	Z= I/y	Z=	0.165267
	y:		0.5	"			
1010 series	I :		0.0441316	"4	Z= I/y	Z=	0.088263
	y		0.5	"			
6105-T5	E		69589	Mpa			
			1.02E+07	psi			

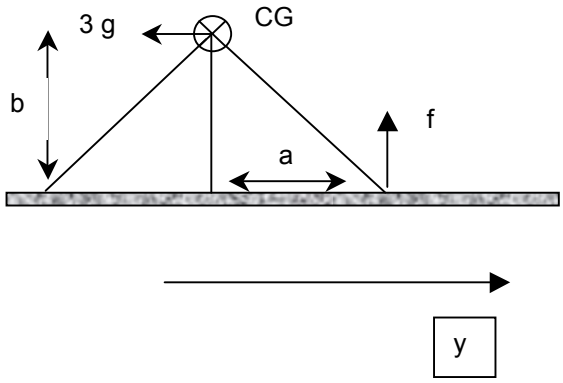
1020 stress at center	12252.91 psi	Tensile Yield Strength	35000
1010 stress at center	22942.74 psi	Ultimate Tensile Strength	38000
1020 max def at center	0.130 "		
1010 max def at center	0.243 "		
1020 Percent of Yield	35.01%	FOS:	2.86
1010 Percent of Yield	65.55%	FOS:	1.53
1020 Percent of Ultimate	32.24%	FOS:	3.10
1010 Percent of Ultimate	60.38%	FOS:	1.66

Subsystem 3: (subsystem 2 + Pallet)



The subsystem 2 is bolted to the pallet on 4 sides.
Along the X-axis three (3) #10 bolts are used on both sides (bolts are in the Z-axis).
Along the Y-axis four (4) 1/4-20 bolts are used on both sides (bolts are in the Z-axis).

We consider only the bolts along the Y-axis (CG centered with the middle plane YZ of the pallet). We assume the 4 bolts on one side form a pivot point for a rigid rotor that puts tension on the 4 bolts located on the other side of the pallet



Assuming tension and shear add, then

Max load per bolt is:
F= 3. Fcg [1/(total number of bolts on both sides)+b/[2x # of bolts under tension..a]

Forward 3g: 3x300 [1/8+10/(8*18)] = 179lb per bolt
Up 2g: 2x300x1/8 = 75lb per bolt

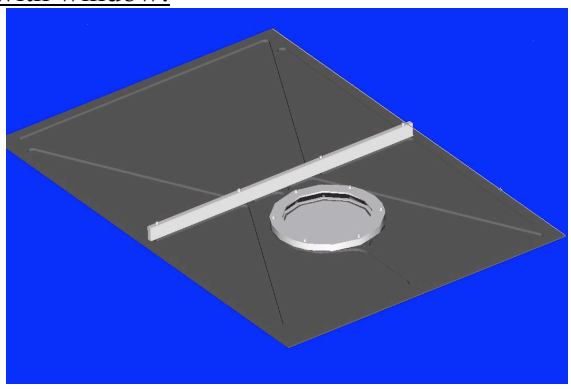
Safety factor :

Rating for a _-28 bolt : 125,000 psi x.049 si =6,135 lb

6135/179=34
FOS= 34

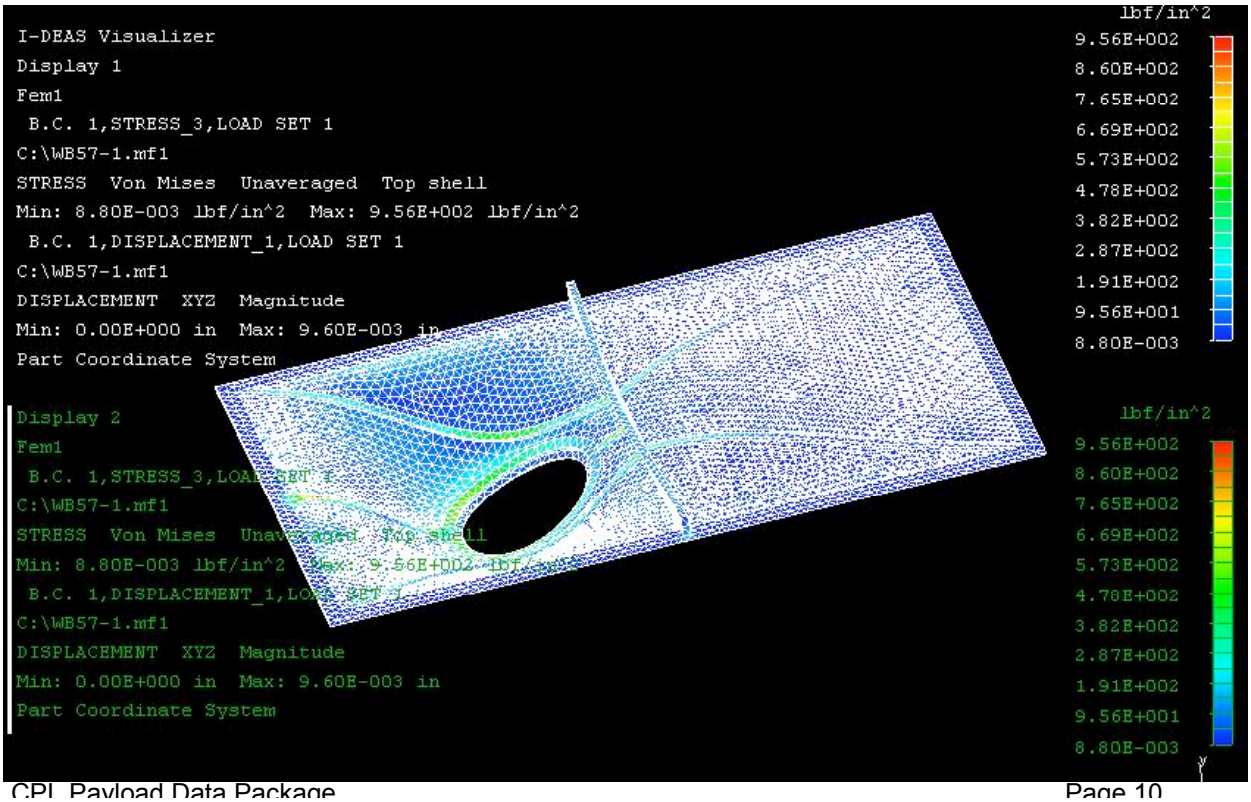
This is without including the effect of the 6 bolts along the X-axis.

Design of the pallet floor with window:



The window is held in place using a retainer bolted with six (6) #10 bolts.
FEA:

Boundary condition used is that the floor is clamped on the 4 sides;
Pressure applied on the recess for the window (total force of 21 lbs).



Design of the shield:

The shield is not a structural part of the system. It has a thermal and "insulation (environment)" purpose. The shield is made of .04" thick 6061 Aluminum.

3. Pressure/Vacuum Systems

There are no pressure or vacuum systems in the CPL instrument.

4. Laser Systems

The CPL instrument utilizes a laser to measure atmospheric properties. The laser is a pulsed Nd:YVO_4 system operating at either 1 kHz or 5 kHz repetition rate (the repetition rate is selected before flight and is not changeable during flight). The CPL laser is high repetition rate, low pulse energy design to enable safe operation during flight. A complete laser safety plan, dated July 8, 2004, has previously been submitted to the WB-57 program office, and that safety plan has been approved by JSC.

5. Hazardous Analysis Report Guidelines

HAZARD SOURCE CHECKLIST

__X__ Flammable/combustible material, fluid (liquid, vapor,gas)

CPL uses small amounts of methanol to clean the optical windows on the instrument. This is only used in pre-flight operations; there are no flammable/combustible materials in the CPL instrument proper. The methanol can be stored in an appropriate cabinet provided by the program office.

_N/A_ Toxic/corrosive/hot/cold material, fluid (liquid, vapor, gas)

_N/A_ High pressure system (static or dynamic)

_N/A_ Evacuated container (implosion)

_N/A_ Frangible material

_N/A_ Stress corrosion susceptible material

_N/A_ Inadequate structural design (i.e., low safety factor)

__X__ High intensity light source (including laser)

CPL utilizes a laser. The CPL is a non-scanning system and the laser points only at nadir (i.e., laser beam exits the WB-57 pallet in the downward direction). The pilot checklist provides control of laser emission (i.e., the laser emission is controlled by a pilot switch). Ground operations do not require operation of the laser. A complete laser safety plan has previously been submitted to the WB-57 program office and the safety plan has been approved by JSC. See also section 3.

_N/A_ Ionizing/electromagnetic radiation

_N/A_ Rotating device

_N/A_ Extendible/deployable/articulating experiment element (collision)

_N/A_ Stowage restraint failure

_N/A_ Stored energy device (i.e., mechanical spring under compression)

_N/A_ Vacuum vent failure (i.e., loss of pressure/atmosphere)

_N/A_ Heat transfer (habitable area over-temperature)

_N/A_ Over-temperature explosive rupture (including electrical battery)

_N/A_ High/Low touch temperatures

__X__ Hardware cooling/heating loss (i.e., loss of thermal control)

There are appropriately sized thermostats wired in series with all instrument heaters.

_N/A_ Pyrotechnic/explosive device

_N/A_ Propulsion system (pressurized gas or liquid/solid propellant)

_N/A_ High acoustic noise level

_N/A_ Toxic of-gassing material

_N/A_ Mercury/mercury compund

_N/A_ Organic/microbiological (pathogenic) contamination source

_N/A_ Sharp corner/edge/protrusion/protuberance

_N/A_ Flammable/combustible material, fluid ignition source (i.e., short circuit; under-sized wiring/fuse/circuit breaker)

__X__ High voltage (electrical shock)

There is high voltage present in one component of the laser power supply and connected to the CPL instrument box via a coaxial cable. This component is potted for operation at low pressure and this component is not accessible unless the power supply is disassembled. The cable running to the CPL instrument box is insulated and rated for operation at low pressure.

_N/A_ High static electrical discharge producer

__X_ Software error or computer fault

The CPL instrument does provide a software/computer error warning. The data system is operated via a pilot switch, and the corresponding pilot fail light will not extinguish until the data system has booted and is operating properly. If, at any time during flight, the data system fails, the pilot fail light will alert the pilot to cycle power (according to the operating sequence provided in section 9.7).

_N/A_ Carcinogenic material

____ Other:_____

6. Ground Support Requirements

Ground power for testing and lab operations: CPL requires only standard 60 Hz 110 VAC. We will have one or two computers for data processing, so having a dedicated circuit would be desirable but not required.

Pressurized gas or cryogenics: CPL requires no gasses or cryogens.

Mixing/storing toxic chemicals: The only chemical/hazardous material used by CPL is methanol used to clean optics. We can store the methanol in an approved cabinet supplied by the WB-57 program office. MSDS sheets for methanol can be found in Appendix A.

Working hours/access: We will require after-hours access to the laboratory space (not to the aircraft). CPL data processing begins immediately after flight, and access to our computers is essential to permit data processing.

Laboratory space requested: We request space for storage of the CPL shipping boxes and facilitation of CPL data processing. The CPL data processing station consists of one computer and assorted support equipment. Two CPL personnel will be on-site at any given time.

Computer network access: We request at least one, and preferably two, network connections to support CPL data processing activities.

Special handling/support equipment: None needed, although a forklift might be helpful in loading/unloading the CPL boxes from a delivery truck.

Miscellaneous requests: None.

7. Hazardous Materials

The only hazardous material used in CPL operations is methanol used to clean the optical windows. There are no hazardous materials in the CPL instrument itself, nor are there any hazardous materials that are used in flight operations. We can store our methanol bottle in any appropriate storage unit, which we assume will be provided by the WB-57 program office.

8. Material Safety Data Sheets (MSDS)

Per section 7, the only hazardous material used is methanol. We will bring a copy of the MSDS with us, and for reference a copy of the MSDS is provided in Appendix A of this document.

9. Mission Procedures

9.1 Equipment Shipment

CPL shipments consist of two large boxes, each 63x63x48 inches and weighing up to 600 lbs each. One box contains the instrument, the other contains support equipment. Transportation is arranged by Goddard Space Flight Center using various contract carriers. We normally arrange for the boxes to arrive 1-2 days ahead of CPL personnel, so we require storage for 1-2 days although there are no particular storage requirements other than storing them in a secure location. We desire to store the boxes in or near our hangar work area, as we prefer to keep the support equipment stored but accessible.

9.2 Ground Operations

Unless there are problems (i.e., equipment failure), CPL requires no ground operations. If the instrument suffers a failure, we have with us support equipment, spare parts, and tools necessary to permit identification and repair of most problems.

Prior to initial integration into the aircraft, we will power the instrument to verify data system integrity. This is accomplished by supplying wall plug power to the instrument and verifying proper operation. This test can be completed with CPL in a laboratory or on the hangar floor.

9.3 Loading

Once on-site, we will bolt our WB-57 interface rack to the WB-57 pallet, and install the CPL instrument onto the interface rack. Placing the 235-lb CPL instrument into the WB-57 pallet will require assistance, usually 2-3 people, to lift it into place. We will assemble our custom pallet floor into the pallet, and install our window into the pallet floor. We will also assemble our thermal enclosure over the instrument.

We have existing cabling as used on the ER-2. Because the electrical interfaces are identical, we will simply re-use the existing cables. A power-up test will be performed to verify instrument operation and fail light operation. When on the aircraft but not immediately ready for flight, we disengage the circuit breakers on the instrument to avoid accidental powering.

9.4 Pre-Flight

Under normal operating conditions, pre-flight activities for CPL are minimal. Pre-flight consists of checking cleanliness of the optical windows and cleaning them if necessary, engaging the circuit breakers located on the instrument, and a quick power-on check to verify that the data system functions properly along with the fail lights. After this short test, the pallet can be loaded into the aircraft and CPL is ready for flight.

9.5 Flight Operations

Once at JSC we will work with the WB-57 program office to define the final flight operation sequence. However, we can outline an expected operation sequence based on previous ER-2 experience. Here we define the pilot switches S1 and S2 to be the data system and laser emission enables, respectively.

For normal flight operation the sequence is as follows:

After Engine Start – MASTER PWR – ON

Area Power	ON	Powers CPL payload, heaters.
S1	ON	Fail light will stay on for 1-2 minutes

After Takeoff

S2	ON	Fail light should extinguish immediately

*Note: If S2 on and fail light off, CPL is radiating

Before Descent

S2	OFF	S2 fail light will activate

Before Engine Shutdown

S1	OFF
Area Power	OFF

If, during flight, either the S1 or S2 fail light activates, then it is necessary to follow a fail procedure, defined as follows:

S2 LIGHT ON: 2 RESET ATTEMPTS

S2 OFF
S2 ON

IF S2 FAIL LIGHT REMAINS ON, CONTINUE

S2 OFF
S1 OFF
S1 ON (WAIT 2 MIN until S1 fail light OFF)
S2 ON

IF S2 FAIL LIGHT REMAINS ON, CONTINUE

S2 OFF
S1 OFF

S1 LIGHT ON: 2 RESET ATTEMPTS

S2 OFF
S1 OFF
S1 ON Wait 2 minutes for S1 fail light to go OFF
(IF S1 LIGHT OFF)
S2 ON
(IF S1 LIGHT ON)
REPEAT ABOVE

If it becomes necessary to disable the CPL payload (i.e., a "hard fail" has occurred and the system appears to be non-functional), it is essential that area power be left ON to power the CPL survival heaters.

9.6 Post-Flight

Unless there is an equipment failure, the CPL instrument is not removed from the WB-57 pallet. We will require the pallet be taken off the plane, so we can access connectors to download data. We connect a laptop computer to the instrument, power the instrument, and transfer data from the instrument. During data transfer, power can be supplied by the aircraft or, we can disconnect the power connector on the instrument and power it from a wall plug. After transferring data to the laptop, all subsequent post-flight activities are conducted in a laboratory using ground support computers, with no further access to the instrument required.

If CPL suffers an equipment failure, then we will remove the instrument from the pallet and move to a laboratory to diagnose and repair the problem.

9.7 Off-Loading

Upon completion of the mission, we will remove the CPL instrument from the WB-57 pallet. We will also remove our optical window and our custom pallet floor. We will retain possession of our pallet floor for use in future missions. The electrical cables running from the CPL instrument to the experimenter interface box will be removed and are the property of CPL.

Goddard Space Flight Center will arrange for pick up of the CPL equipment by a contract carrier.

APPENDIX A

Material Safety Data Sheets (MSDS)

Material Safety Data Sheet
Methanol

ACC# 14280

Section 1 - Chemical Product and Company Identification

MSDS Name: Methanol
Catalog Numbers: S75162, S75163, S75959, S75965, S75965A, S75965HPLC, S75965SPEC, A408-1, A408-4, A408-4LC, A408SK-4, A411-20, A411-4, A412-1, A412-20, A412-200, A412-200LC, A412-4, A412-4LC, A412-500, A412-500LC, A412CU1300, A412FB115, A412FB19, A412FB200, A412FB50, A412J500, A412P-4, A412P-4LC, A412POP19, A412POP200, A412POP50, A412POPB19, A412POPB200, A412POPB50, A412RB115, A412RB200, A412RB50, A412RS115, A412RS19, A412RS200, A412RS28, A412RS50, A412SK-4, A412SS-115, A412SS-19, A412SS-200, A412SS28, A412SS50, A413-20, A413-200, A413-4, A413-500, A433F-1GAL, A433P-4, A433P1GAL, A433RS50, A433S-20, A433S-200, A433S-4, A434-20, A450-4, A452-1, A452-212, A452-4, A452-4LC, A452J1, A452N119, A452N219, A452NB219, A452POP19, A452POP200, A452POP28, A452POP50, A452POPN19, A452RS-115, A452RS-19, A452RS-200, A452RS-28, A452RS-50, A452SK-1, A452SK-4, A452SS-115, A452SS-19, A452SS-200, A452SS-50, A452SS28, A453-1, A453-1LC, A453-500, A453J1, A454-1, A454-1LC, A454-4, A454-4LC, A454J1, A454POP19, A454POP200, A454POP50, A454RS-115, A454RS-200, A454RS-28, A454SS-19, A454SS-28, A454SS-50, A454SS115, A454SS200, A455-1, A455POP19, A455POP200, A455POP50, A455RS19, A455SS19, A455SS200, A455SS50, A457-4, A935-4, A935FB200, A935POPB200, A935RB200, A947-4, A947-4LC, A947POP19, A947POP200, A947POP50, A947RS-115, A947RS-200, A947RS-28, A947SS-115, A947SS-19, A947SS-200, A947SS-28, A947SS-50, BP1105-1, BP1105-4, BP1105POP19, BP1105POP20, BP1105POP50, BP1105SS115, BP1105SS19, BP1105SS200, BP1105SS28, BP1105SS50, BP2618100, HC400 1GAL, NC9105104, NC9115030, NC9125138, NC9134255, NC9173853, NC9905242, NC9942270, NC9964975, SC95-1, SW2-1, TIA9474, TIA947P200L
Synonyms: Carbinol; Methyl alcohol; Methyl hydroxide; Monohydroxymethane; Wood alcohol; Wood naptha; Wood spirits; Columbian spirits; Methanol.
Company Identification:

Fisher Scientific
1 Reagent Lane
Fair Lawn, NJ 07410

For information, call: 201-796-7100
Emergency Number: 201-796-7100
For CHEMTREC assistance, call: 800-424-9300
For International CHEMTREC assistance, call: 703-527-3887

Section 2 - Composition, Information on Ingredients

CAS#	Chemical Name	Percent	EINECS/ELINCS

67-56-1	Methanol	>99.0	200-659-6

Hazard Symbols: T F
Risk Phrases: 11 23/24/25 39/23/24/25

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Appearance: clear, colorless liquid. Flash Point: 11 deg C. Poison! Cannot be made non-poisonous. Causes eye and skin irritation. **Danger!** **Flammable liquid and vapor.** May be fatal or cause blindness if swallowed. May cause central nervous system depression. Causes respiratory tract irritation. Harmful if swallowed, inhaled, or absorbed through the skin. Vapor harmful.
Target Organs: Eyes, nervous system, optic nerve.

Potential Health Effects
Eye: Methanol is a mild to moderate eye irritant. Inhalation, ingestion or skin absorption of methanol can cause significant disturbances in vision, including blindness.
Skin: Causes moderate skin irritation. Harmful if absorbed through the skin. Prolonged and/or repeated contact may cause defatting of the skin and dermatitis. Methanol can be absorbed through the skin, producing systemic effects that include visual disturbances.
Ingestion: Harmful if swallowed. May be fatal or cause blindness if swallowed. Aspiration hazard. May cause systemic toxicity with acidosis. May cause central nervous system depression, characterized by excitement, followed by headache, dizziness, drowsiness, and nausea. Advanced stages may cause collapse, unconsciousness, coma and possible death due to respiratory failure.
Inhalation: Methanol is toxic and can very readily form extremely high vapor concentrations at room temperature. Inhalation is the most common route of occupational exposure. At first, methanol causes CNS depression with nausea, headache, vomiting, dizziness and incoordination. A time period with no obvious symptoms follows (typically 8-24 hrs). This latent period is followed by metabolic acidosis and severe visual effects which may include reduced reactivity and/or increased sensitivity to light, blurred, double and/or snowy vision, and blindness. Depending on the severity of exposure and the promptness of treatment, survivors may recover completely or may have permanent blindness, vision disturbances and/or nervous system effects.
Chronic: Prolonged or repeated skin contact may cause dermatitis. Chronic exposure may cause effects similar to those of acute exposure. Methanol is only very slowly eliminated from the body. Because of this slow elimination, methanol should be regarded as a cumulative poison. Though a single exposure may cause no effect, daily exposures may result in the accumulation of a harmful amount. Methanol has produced fetotoxicity in rats and teratogenicity in mice exposed by inhalation to high concentrations that did not produce significant maternal toxicity.

Section 4 - First Aid Measures

Eyes: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical aid.
Skin: In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid immediately. Wash clothing before reuse.
Ingestion: Potential for aspiration if swallowed. Get medical aid immediately. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person.
Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.
Notes to Physician: Effects may be delayed.
Antidote: Ethanol may inhibit methanol metabolism.

Section 5 - Fire Fighting Measures

General Information: Containers can build up pressure if exposed to heat and/or fire. As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Use water spray to keep fire-exposed containers cool. Water may be ineffective. Material is lighter than water and a fire may be spread by the use of water. Flammable liquid and vapor. Vapors are heavier than air and may travel to a source of ignition and flash back. Vapors can spread along the ground and collect in low or confined areas.
Extinguishing Media: For small fires, use dry chemical, carbon dioxide, water spray or alcohol-resistant foam. Water may be ineffective. For large fires, use water spray, fog or alcohol-resistant foam. Do NOT use straight streams of water.
Flash Point: 11 deg C (51.80 deg F)
Autoignition Temperature: 464 deg C (867.20 deg F)
Explosion Limits, Lower:6.0 vol %
Upper: 36.00 vol %
NFPA Rating: (estimated) Health: 1; Flammability: 3; Instability: 0

Section 6 - Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks: Absorb spill with inert material (e.g. vermiculite, sand or earth), then place in suitable container. Use water spray to disperse the gas/vapor. Remove all sources of ignition. Provide ventilation. A vapor suppressing foam may be used to reduce vapors. Water spray may reduce vapor but may not prevent ignition in closed

spaces.

Section 7 - Handling and Storage

Handling: Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Ground and bond containers when transferring material. Avoid contact with eyes, skin, and clothing. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep container tightly closed. Do not ingest or inhale. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose empty containers to heat, sparks or open flames. Use only with adequate ventilation. Keep away from heat, sparks and flame. Avoid use in confined spaces. Avoid breathing vapor or mist.
Storage: Keep away from heat, sparks, and flame. Keep away from sources of ignition. Store in a cool, dry, well-ventilated area away from incompatible substances. Flammables-area. Keep containers tightly closed.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls: Use explosion-proof ventilation equipment. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits.
Exposure Limits

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Methanol	200 ppm TWA; 250 ppm STEL; skin - potential for cutaneous absorption	200 ppm TWA; 260 mg/m3 TWA 6000 ppm IDLH	200 ppm TWA; 260 mg/m3 TWA

OSHA Vacated PELs: Methanol: 200 ppm TWA; 260 mg/m3 TWA
Personal Protective Equipment
Eyes: Wear chemical goggles.
Skin: Wear appropriate protective gloves to prevent skin exposure.
Clothing: Wear appropriate protective clothing to prevent skin exposure.
Respirators: A respiratory protection program that meets OSHA's 29 CFR 1910.134 and ANSI Z88.2 requirements or European Standard EN 149 must be followed whenever workplace conditions warrant a respirator's use.

Section 9 - Physical and Chemical Properties

Physical State: Liquid
Appearance: clear, colorless
Odor: alcohol-like - weak odor
pH: Not available.
Vapor Pressure: 127 mm Hg @ 25 deg C

Vapor Density: 1.11 (Air=1)
Evaporation Rate:5.2 (Ether=1)
Viscosity: 0.55 cP 20 deg C
Boiling Point: 64.7 deg C @ 760 mm Hg
Freezing/Melting Point:-98 deg C
Decomposition Temperature: Not available.
Solubility: miscible
Specific Gravity/Density:.7910 g/cm3 @ 20°C
Molecular Formula:CH4O
Molecular Weight:32.04

Section 10 - Stability and Reactivity

Chemical Stability: Stable under normal temperatures and pressures.
Conditions to Avoid: High temperatures, ignition sources, confined spaces.
Incompatibilities with Other Materials: Strong oxidizing agents, strong acids, powdered aluminum, powdered magnesium.
Hazardous Decomposition Products: Carbon monoxide, irritating and toxic fumes and gases, carbon dioxide, formaldehyde.
Hazardous Polymerization: Will not occur.

Section 11 - Toxicological Information

RTECS#:
CAS# 67-56-1: PC1400000
LD50/LC50:
CAS# 67-56-1:
Draize test, rabbit, eye: 40 mg Moderate;
Draize test, rabbit, eye: 100 mg/24H Moderate;
Draize test, rabbit, skin: 20 mg/24H Moderate;
Inhalation, rabbit: LC50 = 81000 mg/m3/14H;
Inhalation, rat: LC50 = 64000 ppm/4H;
Oral, mouse: LD50 = 7300 mg/kg;
Oral, rabbit: LD50 = 14200 mg/kg;
Oral, rat: LD50 = 5600 mg/kg;
Skin, rabbit: LD50 = 15800 mg/kg;

Carcinogenicity:
CAS# 67-56-1: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.
Epidemiology: No data available.
Teratogenicity: There is no human information available. Methanol is considered to be a potential developmental hazard based on animal data. In animal experiments, methanol has caused fetotoxic or teratogenic effects without maternal toxicity.
Reproductive Effects: See actual entry in RTECS for complete information.

Neurotoxicity: ACGIH cites neuropathy, vision and CNS under TLV basis.
Mutagenicity: See actual entry in RTECS for complete information.
Other Studies: No data available.

Section 12 - Ecological Information

Ecotoxicity: Fish: Fathead Minnow: 29.4 g/L; 96 Hr; LC50 (unspecified)Fish: Goldfish: 250 ppm; 11 Hr; resulted in deathFish: Rainbow trout: 8000 mg/L; 48 Hr; LC50 (unspecified)Fish: Rainbow trout: LC50 = 13-68 mg/L; 96 Hr.; 12 degrees CFish: Fathead Minnow: LC50 = 29400 mg/L; 96 Hr.; 25 degrees C, pH 7.63Fish: Rainbow trout: LC50 = 8000 mg/L; 48 Hr.; UnspecifiedBacteria: Phytobacterium phosphoreum: EC50 = 51,000-320,000 mg/L; 30 minutes; Microtox test No data available.
Environmental: Dangerous to aquatic life in high concentrations. Aquatic toxicity rating: TLm 96>1000 ppm. May be dangerous if it enters water intakes. Methyl alcohol is expected to biodegrade in soil and water very rapidly. This product will show high soil mobility and will be degraded from the ambient atmosphere by the reaction with photochemically produced hyroxyl radicals with an estimated half-life of 17.8 days. Bioconcentration factor for fish (golden ide) < 10. Based on a log Kow of -0.77, the BCF value for methanol can be estimated to be 0.2.
Physical: No information available.
Other: No information available.

Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.
RCRA P-Series: None listed.
RCRA U-Series: CAS# 67-56-1: waste number U154 (Ignitable waste).

Section 14 - Transport Information

	US DOT	IATA	RID/ADR	IMO	Canada TDG
Shipping Name:	METHANOL (METHANOL)				METHANOL (METHANOL)
Hazard Class:	3				3(6.1)
UN Number:	UN1230				UN1230
Packing Group:	II				II

Section 15 - Regulatory Information

US FEDERAL

TSCA
CAS# 67-56-1 is listed on the TSCA inventory.
Health & Safety Reporting List
None of the chemicals are on the Health & Safety Reporting List.
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.
SARA

CERCLA Hazardous Substances and corresponding RQs
CAS# 67-56-1: 5000 lb final RQ; 2270 kg final RQ
SARA Section 302 Extremely Hazardous Substances
None of the chemicals in this product have a TPQ.
SARA Codes
CAS # 67-56-1: acute, flammable.
Section 313
This material contains Methanol (CAS# 67-56-1, 99 0%),which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.
Clean Air Act:
CAS# 67-56-1 is listed as a hazardous air pollutant (HAP). This material does not contain any Class 1 Ozone depletors. This material does not contain any Class 2 Ozone depletors.
Clean Water Act:
None of the chemicals in this product are listed as Hazardous Substances under the CWA. None of the chemicals in this product are listed as Priority Pollutants under the CWA. None of the chemicals in this product are listed as Toxic Pollutants under the CWA.
OSHA:
None of the chemicals in this product are considered highly hazardous by OSHA.
STATE
CAS# 67-56-1 can be found on the following state right to know lists: California, New Jersey, Pennsylvania, Minnesota, Massachusetts.
California No Significant Risk Level: None of the chemicals in this product are listed.

European/International Regulations

European Labeling in Accordance with EC Directives
Hazard Symbols:
T F
Risk Phrases:
R 11 Highly flammable.
R 23/24/25 Toxic by inhalation, in contact with skin

and if swallowed.
R 39/23/24/25 Toxic : danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.

Safety Phrases:
S 16 Keep away from sources of ignition - No smoking.
S 36/37 Wear suitable protective clothing and gloves.
S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S 7 Keep container tightly closed.

WGK (Water Danger/Protection)
CAS# 67-56-1: 1
Canada - DSL/NDSL
CAS# 67-56-1 is listed on Canada's DSL List.
Canada - WHMIS
This product has a WHMIS classification of B2, D1B, D2B.
Canadian Ingredient Disclosure List
CAS# 67-56-1 is listed on the Canadian Ingredient Disclosure List.
Exposure Limits
CAS# 67-56-1: OEL-ARAB Republic of Egypt:TWA 200 ppm (260 mg/m3);Ski n OEL-AUSTRALIA:TWA 200 ppm (260 mg/m3);STEL 250 ppm;Skin OEL-BELGIU M:TWA 200 ppm (262 mg/m3);STEL 250 ppm;Skin OEL-CZECHOSLOVAKIA:TWA 10 0 mg/m3;STEL 500 mg/m3 OEL-DENMARK:TWA 200 ppm (260 mg/m3);Skin OEL-FINLAND:TWA 200 ppm (260 mg/m3);STEL 250 ppm;Skin OEL-FRANCE:TWA 200 ppm (260 mg/m3);STEL 1000 ppm (1300 mg/m3) OEL-GERMANY:TWA 200 ppm (2 60 mg/m3);Skin OEL-HUNGARY:TWA 50 mg/m3;STEL 100 mg/m3;Skin JAN9 OEL -JAPAN:TWA 200 ppm (260 mg/m3);Skin OEL-THE NETHERLANDS:TWA 200 ppm (260 mg/m3);Skin OEL-THE PHILIPPINES:TWA 200 ppm (260 mg/m3) OEL-POLA ND:TWA 100 mg/m3 OEL-RUSSIA:TWA 200 ppm;STEL 5 mg/m3;Skin OEL-SWEDEN :TWA 200 ppm (250 mg/m3);STEL 250 ppm (350 mg/m3);Skin OEL-SWITZERLAN D:TWA 200 ppm (260 mg/m3);STEL 400 ppm;Skin OEL-THAILAND:TWA 200 ppm (260 mg/m3) OEL-TURKEY:TWA 200 ppm (260 mg/m3) OEL-UNITED KINGDOM:TW A 200 ppm (260 mg/m3);STEL 250 ppm;Skin OEL IN BULGARIA, COLOMBIA, JO RDAN, KOREA check ACGIH TLV OEL IN NEW ZEALAND, SINGAPORE, VIETNAM ch eck ACGI TLV

Section 16 - Additional Information

MSDS Creation Date: 7/21/1999
Revision #11 Date: 10/21/2002

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall

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